

Incidence and predictors of difficult mask ventilation and intubation

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Abstract

Background: This study is aimed to determine the incidence and predictors of difficult and impossible mask ventilation.

Materials and Methods: Information like age, snoring history, obstructive sleep apnea, dental and mandibular abnormalities, macroglossia, grading like SLUX, Mallampatti, Cormack Lehanne, atlantooccipital extension, presence of beard or moustache, mouth opening were collected. During mask ventilation, the information related to the ventilation and intubation was collected. All variables found to be significant in univariate analysis were subjected to the multivariate logistic regression model to identify independent predictors of measured outcome.

Results: Difficult mask ventilation (DMV) was observed in 30 male patients and 9 female patients. Of the 40 patients who had difficult intubation (DI), 7 patients had both DMV and intubation and 1 patient was of impossible mask ventilation/ intubation. Snoring was the lone significant risk factor for DMV. The risk factors identified for DI were snoring, retrognathia, micrognathia, macroglossia, short thick neck, Mallampatti grade [III/IV], abnormal SLUX grade, Cormack Lehanne grade [II,III/IV], abnormal atlantooccipital extension grading, flexion/extension deformity of neck, protuberant teeth, cervical spine abnormality, mouth opening < 3 cm, and BMI > 26 kg/m². BMI > 26 kg/m² and atlantooccipital extension grade > 3 were independent risk factors for DI and the presence of two of the variables made the sensitivity and specificity of 43% and 99% respectively with a positive predictive value of 74%.

Conclusions: The predictive score may lead to a better anticipation of difficult airway management, potentially decreasing the morbidity and mortality resulting from hypoxia or anoxia with failed ventilation.

Key words: Airway, difficult ventilation, difficult intubation, mask

Introduction

The responsibility of anesthesiologist is to maintain airway patency for better oxygenation of the tissues. Failure to access an airway during emergency or elective surgeries can result in hypoxic brain injury. Ability to ventilate the patient with bag and mask is extremely important in the unfortunate scenario of inability to intubate. Mask ventilation is often not considered important. We find that intubation may be easy even though

mask ventilation is difficult. There is limited data on difficult mask ventilation (DMV). This prospective study was done to find the incidence and predictive factors for the impossible and DMV and difficult intubation (DI) in routine day to day cases.

Materials and Methods

DMV is subjectively defined when signs of inadequate ventilation like gas leak around the mask, no perceptible chest movements, oxygen saturation less than 92% by pulse oxymetry are seen and alternative methods to facilitate mask ventilation is required e.g. two-handed mask ventilation, insertion of oropharyngeal or nasopharyngeal airway and change of operator during general anesthesia.^[1] DI is defined when the operator takes more than two attempts or 9 minutes for intubation and Cormack Lehanne grade more than two on laryngoscopy.

The approval of the Ethics Committee of the Institute was taken to conduct the study. After informed written consent was taken, all adult patients, over a 1 year period, scheduled for orthopedic, urologic, abdominal, gynecologic,

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cardiovascular, and neurosurgery who would need mask ventilation and endotracheal intubation during general anesthesia were prospectively included in this trial. Pediatric patients, procedures done with regional anesthesia and those with contraindications for mask ventilation [rapid sequence induction, awake intubation in case of expected difficult airway] were excluded from the study. The sample size required for our study calculated was 436 with 95% confidence interval after considering the study done by Langeron.^[1] After taking into consideration the factor of drop outs, 500 patients were included in the study. All episodes of DMV and intubation were recorded.

At the time of induction, during mask ventilation, the information related to the ventilation and intubation were collected by an anesthesiologist. The parameters used for assessing difficult ventilation and intubation like age, snoring history, obstructive sleep apnea, dental and mandibular abnormalities, macroglossia, presence of beard or moustache, grading like SLUX, Mallampatti, atlantooccipital extension and mouth opening were collected during, the preoperative visit or just before the surgery. Cormack Lehanne grade of laryngoscopy view was assessed during laryngoscopy.

We used the standardized routine procedure for tracheal intubation followed in our hospital. The patient's head and neck were placed in a sniffing position with an appropriately sized head ring so that the head of the patient remains in neutral position to improve laryngoscopy with Macintosh Laryngoscope blade and intubation outcome. Preoxygenation of each patient for 4 minutes with 100% oxygen was done with help of a face mask. Each patient was routinely monitored during the whole procedure by electrocardiography, peripheral oxygen saturation (SpO_2), and end-tidal carbon dioxide. After intubation with muscle relaxation, the correct positioning of the endotracheal tube was confirmed by bilateral auscultation of lungs and curve analysis of carbon dioxide in the exhaled gas.

We evaluated different factors such as age, gender, body mass index, experience level of anesthesiologist, history of snoring, presence of beard, inter incisor gap, thyromental distance, sternomental distance, degree of head extension, presence of airway deformity, and receding mandible as predictors of DMV and intubation.

Univariate analysis was performed between patients with or without the following measured outcome. Statistical significance was tested using the Pearson chi-square/Fischer exact test. All variables found significant in univariate analysis were subjected to multivariate logistic regression model to identify independent predictors of measured outcome. Binary logistic regression analysis was used to identify significant predictors

of DMV and DI. All the variables were entered at the same time [by using ENTER model in SPS]. Factors showing the P value < 0.05 were considered significant predictors. Omnibus test model coefficient was statistically significant, indicating model is appropriate. Nagelkerke R^2 value is 0.70 indicating 70% variation of DI can be explained by significant factors. Hosmer Lomeshow goodness of fit test revealed model fit as the P value is more than 0.05. Results of regression coefficients and odds ratio with 95% confidence interval are shown in table.

Odds ratios were analyzed to assess diagnostic value of risk factors scale. The independent risk factors identified by logistic regression were subjected to risk factor scale to predict the outcome. Receiver operating characteristic curves were analyzed to assess the diagnostic value of risk factor scale.

Results

A total of 500 patients, 329 males and 171 females, were sampled. DMV was observed in 30 male patients and 9 female patients. There was no significant difference in the DMV among the male and female patients. DI was observed in 30 male patients and 10 female patients and there was no statistical difference between the two. Gender was not a predictive factor for both DMV and DI.

Incidence of DMV was 12.82% [39 out of 500 patients]. The risk factors identified for DMV were snoring, obstructive sleep apnea, retrognathia, micrognathia, macroglossia, edentulous teeth, short thick neck, Mallampatti grade [III/IV], abnormal SLUX grade, abnormal, experience level of anesthetist, Cormack Lehanne grade [III/IV], and $\text{BMI} > 26 \text{ kg/m}^2$. The risk factors identified for DI were snoring, retrognathia, micrognathia, macroglossia, short thick neck, Mallampatti grade [III/IV], abnormal SLUX grade, Cormack Lehanne grade [III, III/IV], abnormal atlantooccipital extension grading, flexion/extension deformity of neck, protuberant teeth, cervical spine abnormality, mouth opening in cms and $\text{BMI} > 26 \text{ kg/m}^2$.

Statistical analysis showed that DMV was significantly more with increasing Mallampatti grade. Mask ventilation was difficult in five [31.3%] patients with Mallampatti grade III and only one patient in our study had Mallampatti grade IV and that patient also had DMV. Similarly, increasing Mallampatti grade was associated with DI with an incidence of 37.3% [5 out of 10] in class III and 100% in class IV, as the only one patient with Mallampatti grade IV had DI (P 0.00000).

During the period of study there was one case of impossible mask ventilation/ intubation in which fiberoptic bronchoscopy

aided intubation was performed. This case was excluded from our study.

Univariate analysis demonstrated several risk factors associated with DMV and DI [Table 1]. In a patient, more than one factor could be attributed for DMV or DI. The risk factors identified for DMV by univariate analysis were snoring [5 out of 39], obstructive sleep apnea [2 of 39], retrognathia [1 out of 39], micrognathia [1 out of 39], macroglossia [4 out of 39], edentulous teeth [3 out of 39], short thick neck [5 out of 39], Mallampatti grade [III/IV] [5 out of 39], abnormal SLUX grade [5 out of 39], experience level of anesthesiologist [12 out of 39], Cormack Lehanne grade [III/IV] (17 out of 39), and BMI >26 kg/m² [11 out of 39]. As Cormack Lehanne grade cannot be assessed in the preoperative examination, it was excluded from the multivariate analysis. Age, fracture mandible, loose/missing teeth, atlantooccipital joint extension, mouth opening < 3 cm were excluded because of the insignificant *P* values.

The risk factors identified for DI were snoring [20 out of 40], retrognathia [1 out of 40], micrognathia [1 out of 40], macroglossia [12 out of 40], short thick neck [10 out of 40], Mallampatti grade [III/IV] [6 out of 40], abnormal SLUX grade [6 out of 40], experience level of anesthesiologist [23 out of 40], Cormack Lehanne grade [III/IV] [12 out of 40], abnormal atlantooccipital extension grading [9 out of 40], flexion/extension deformity of neck [6 out of 40], protuberant teeth [4 out of 40], cervical spine abnormality [4 out of 40], mouth opening in cm [5 out of 40], and BMI > 26 kg/m² [23 out of 40].

All the significant risk factors with *P* value < 0.05 found by univariate analysis were included in multivariate analysis to identify independent predictors for difficult airway. The independent predictor for DMV identified was snoring with a significant *P* value of 0.004. Multivariate analysis identified snoring as an independent predictor for DMV. BMI >26 kg/m², and abnormal atlantooccipital extension grading were independent risk factors for DI. Of the 39 cases of DMV only seven patients had DI. Multivariate analysis was not done for the seven cases which had both DMV and DI due to insignificant sample size.

The receiver operating characteristic curve (ROC) curve assist practitioners in evaluating an appropriate cut off for tests that possess a range of scores. Predictive value for DI using the empirical ROC Curve was plotted [Table 2 and Figure 1]. There were three independent risk factor found on binary logistic regression. Each of them was given a score of 1, if they were present and a composite risk factor scale was computed. ROC analysis was used to decide cut off risk score

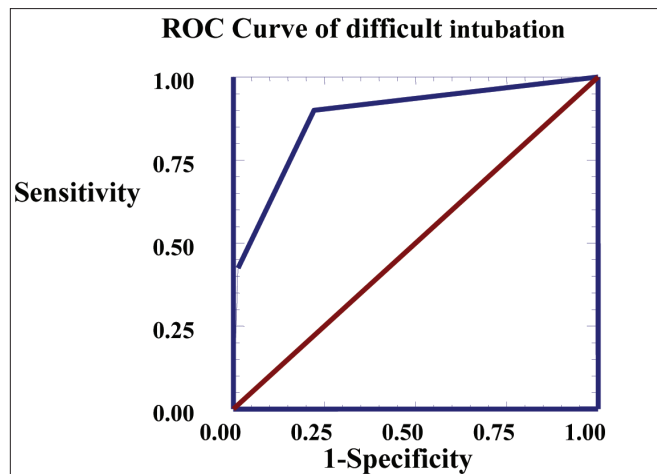


Figure 1: ROC plot section for difficult intubation

[(i.e.) number of risk factors for predicting this DI]. The area under the curve was 0.88 which is significant with *P* 0.0000.

Among patients who were intubated (*n* = 500), DI with Cormack and Lehanne grades III and IV occurred significantly more frequently in patients with DMV [Table 1]. DI was two to threefold more frequent in patients with DMV than those without DMV. Moreover, the incidence of a difficult ventilation- DI was 1.4%. The three independent predictors of DI were used to create a prediction score. A patient was given one point if a pre operative predictor was noted. The risk factor score [Table 3] shows that 32.6 times more chance of DI when two risk factors were present as compared to none. Sensitivity of the score was 43% and specificity was 99% with two risk factors indicates 43% chance of DI if two risk factors were present or 99% chance of easy intubation if both the risk factors were absent. The positive predictive value (PPV) of this test was 74% in patients with two risk factors, as compared to 8% in patients with no risk factor. The risk factors identified in the multivariate analysis and listed in Table 1 were pooled together to determine the DMV prediction score. The number of retained criteria in the DI prediction score associated with the best sensitivity and specificity was two [Table 4]. We also tried to use a weighted score (using the odds ratio), but the accuracy was not significantly improved as compared with the non-weighted score.

One case of impossible mask ventilation and intubation was observed in our study. It was well anticipated before induction and fiber optic intubation was done. Risk factor analysis was not done.

Discussion

In our prospective study, we found that the incidence of DMV was 7.5% and DI was 8%. 17 out of 39 patients with Cormack

Table 1: Univariate predictors of airway outcomes

	Difficult mask ventilation			Difficult intubation		
	No	Yes	P Value	No	Yes	P Value
Age > 55 years	299	30	0.127	299	30	0.201
Snoring	37	15	0.000	32	20	0.000
OSA	5	2	0.039	6	1	0.537
Experience level of anesthesiologist	75	12	0.002	64	23	0.000
Beard	13	2	0.417	14	1	0.847
Edentulous	9	3	0.025	11	1	0.966
Loose/missing teeth	13	2	0.417	13	2	0.439
Protuberant teeth	18	2	0.708	16	4	0.043
Fracture mandible	6	2	0.067	8	0	0.400
Micrognathia	0	1	0.001	0	1	0.001
Retrognathia	0	1	0.001	0	1	0.001
SLUX grade	8	5	0.000	7	6	0.000
Atlanto occipital extension grade	24	2	0.720	17	9	0.000
Mallalpatti grade [III/IV]	11	5	0.000	10	6	0.000
Cormack Lehanne grade [III and IV]	55	17	0.000	60	12	0.003
Body mass index > 26 kg/m ²	53	11	0.003	41	23	0.000
Cervical spine abnormality	18	0	0.209	14	4	0.023
Macroglossia	10	4	0.003	2	12	0.000
Short thick neck	15	5	0.003	10	10	0.000
Mouth opening in cms <3 cm	8	2	0.180	7	3	0.007

Table 2: Empirical area under curve analysis for condition= Difficult intubation

Criterion	AUC	S.E. AUC	Z-Value	P Value
Difficult intubation RF score	0.88	0.028	13.44	0.000

Lehanne grade [III/IV] had DI too. Snoring, obstructive sleep apnea, retrognathia, micrognathia, macroglossia, edentulous teeth, short thick neck, Mallampatti grade [III/IV] grade, abnormal SLUX grade, Cormack Lehanne grade [II,III/IV], and BMI > 26 kg/m² were independent risk factors for DMV. In our study only one patient had more than one factor for DMV.

Incidence of DMV has been assessed in some previous studies, but no previous studies compared all the predictors for mask ventilation and intubation. Lower rates of DMV have been reported in studies by Langeron *et al*^[1] (5%), Asai *et al*^[2] (1.4%), Rose and Cohen^[3] (0.9%), El-Ganzouri^[4] (0.07%). In a retrospective study of 2000 incident reports during anesthesia, DMV incidence reached 15% when DI occurred. SpO₂ was not recorded in the study by El-Ganzouri *et al*. Different predictive factors and non standardized definitions were the reasons for this incidence difference. DMV occurred more frequently in our study (30.9%), and our findings were similar to those of Langeron *et al* (30%). Our findings are also similar to the 30% DMV incidence reported in a prospective audit of failure to intubate in a maternity unit. We found that the DMV and intubation occurred in 1.4% of cases, an incidence almost similar to the previously reported Langeron *et al* study (1.5%).

Kheterpal *et al*^[5] and Han *et al*^[6] found that the incidence of DMV was 1.6% which was much lower than our study

In our study, DMV was anticipated by the anesthesiologist during the preoperative visit in only 21% [after excluding the Cormack Lehanne grade] of the DMV cases. Langeron *et al* reported that in 17% of cases. Asai *et al* reported that in 57% of patients in whom ventilation through a face mask was difficult, no airway problems had been anticipated before induction of anesthesia. In our study, muscle relaxant was used in all the patients involved in study as previously reported by Rose and Cohen. The above results support the need to identify predicting factors for DMV, to decrease the incidence of unexpected difficult ventilation after induction of general anesthesia, and to make more discerning use of muscle relaxants.

In our study snoring was the only independent risk factor identified by the multivariate analysis which is not correlated with the study of Langeron *et al* in which BMI > 26 kg/m², lack of teeth, beard were also independent risk factors in addition to the snoring history. Snoring is due to the reduced posterior airway space behind the base of the tongue which impairs the airway patency during sleep and an upper airway obstruction can occur after induction of general anesthesia. We found that the DMV can be anticipated in a patient with history of snoring during preoperative assessment.

Multivariate analysis identified BMI > 26 kg/m², and abnormal atlantooccipital extension grading were independent risk factors

Table 3: Difficult intubation risk factor score

Cutoff Value difficult intubation RF score	Sensitivity (%)	Specificity (%)	Odds ratio	Positive predictive value	Negative predictive value
0	100	0	1.0	8	100
1	90	78	4.1	26	99
2	43	99	32.6	74	95

Table 4: Independent predictor's difficult intubation

Factors	P Value
Atlanto-occipital joint extension grade	0.000
Body mass index	0.001

for DI. A reduced posterior airway space behind the base of the tongue is associated with an increased BMI. It impairs the airway patency during sleep, and upper airway obstruction. It can occur after induction of general anesthesia with displacements of the soft tissues like palate, epiglottis, and base of tongue cause major secondary collapse of the pharynx with multiple site obstruction.

It is important to consider the independent risk factors for DI, as it can be prevented or anticipated by the BMI or atlantooccipital extension grading. Consequently, these two criteria should be included in the preoperative assessment to detect DI scenario.

The three independent predictors of DI were used to create a prediction score. A patient was given one point if a preoperative predictor was noted. The risk factor score we had created as shown in the Table 3 showed that more chance of DI was there when two risk factors were present as compared to none. Sensitivity of the score was 43% and specificity was 99% with two risk factors. This indicates 43% chance of DI if two risk factors were present or 99% chance of easy intubation if both the risk factors were absent. The PPV of this test was 74% with two risk factors as compared to 8 % with no risk factor.

A receiver operating characteristic curve evaluated the sensitivity and specificity of risk factors for DI. Independent predictors for DI observed were body mass index of 26 kg/m² or abnormal atlanto-occipital extension grade. A prediction score for DI was based on how many of these risk factors a patient possessed.

The DMV definition is a subjective one and observer dependent, hence the variation in the incidence among different studies. As the study was done in a general adult population the results cannot be extrapolated for the pediatric

age group. The independent variables for the DMV are different from the previous study due to the different social or ethnic groups and the difference in size of the population. As the number of patients with DMV and DI were very low the power of such analysis was low, so further study is needed for the accurate prediction of variables.

Ability to more accurately predict DMV and DI can improve safety in airway management. We found snoring as the only risk factor for DMV. We have devised a simple DI risk score. BMI > 26 kg/m² and atlantooccipital extension grade > 3 were found to be independent risk factors for DI. Presence of two of the variables makes the sensitivity and specificity of 43% and 99% respectively with a PPV of 74%. This prediction score is an indicator of difficult airway and may lead to a better anticipation of difficult airway management, potentially decreasing the morbidity and mortality resulting from hypoxia or anoxia with failed ventilation.

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